A CASE OF SUTURE OF THE HEART, WITH RECOVERY.*

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I am indebted to Professor Keen for the privilege of operating upon and reporting the following case:

T. E., aged twenty years, colored, cook, was admitted to the Jefferson Hospital, February 29, 1904. He had been stabbed in the chest with a long, rusty pen-knife. The stab caused severe pain, but neither felled him to the ground nor caused him to feel faint. He walked without assistance to the hospital, a distance of one and a half squares, then began to feel weak, and was found crawling up the steps leading to the entrance of the hospital. After being disrobed a small wound was found just above the third rib, about one inch to the left of the left margin of the sternum. The wound was surrounded by an emphysematous swelling, and bled continuously, the stream of blood being accelerated by each expiration. The temperature was 97°, and the pulse 80, empty and markedly irregular in volume and rhythm. He lay on the right side, breathing forty times per minute in a short, jerky manner. At times he would complain of a little pain and severe dyspnœa. He was sweating and very pale, and had vomited once. There was neither cough nor blood-spitting. Entire left chest was tympanitic on percussion, except for a small area around the wound. On auscultation the heart beats could be heard indistinctly; there was no bruit nor splashing sound. Under ether anæsthesia operation was begun about forty-five minutes after the infliction of the injury. Time of operation about forty-five minutes. Amount of ether, four ounces. An incision was carried along the second rib for four inches to the sternum, then down the left margin of the sternum to the fourth rib and outward along the fourth rib for four inches. The musculocutaneous flap was dissected back and the opening in the chest found between the third and fourth ribs, the knife having descended after passing through the skin. The exposure was then made more complete by continuing the sternal incision downward for two inches, and the triangular flap thus formed retracted. The third and fourth ribs were severed and forcibly turned toward the right, fracturing the costal cartilages near the sternum. The knife had passed through the pleural cavity and wounded the anterior edge of the left lung. The lung had collapsed into the vertebral gutter, and the pleural cavity contained a large quantity of clotted and fluid blood. The opening into the pericardium was easily found by the spurting of blood with each pulsation of the heart; it measured about three-eighths of an inch. The pericardial wound was enlarged in the axis of the heart, and a penetrating wound of the anterior wall of the left ventricle found. This wound was parallel to the axis of the heart, nearer the auricle than the apex, and measured about three-quarters of an inch (larger than either the skin, intercostal, pleural, or pericardial wounds). Bleeding from this wound was free and continuous, whether more marked during diastole I am unable to state, as the heart was now beating very rapidly and resembled a quivering mass of muscle. The wound was closed with a continuous silk suture (six stitches), the sutures being inserted and tied without reference to diastole for the reason already stated. During the suturing the coronary artery was punctured by the needle, causing a profuse hemorrhage which was controlled by an additional suture. The pericardial and pleural cavities were cleared of blood, and the pleural cavity was irrigated with salt solution. The pericardial wound was sutured with a continuous silk suture, a small opening being left at the lower end for the passage of a gauze drain. No attempt was made to suture the lung (which was not bleeding) nor the parietal pleura. A gauze drain was also placed in the pleural cavity, gaining exit at the lower part of the primary incision. The severed ribs were approximated and the soft parts sutured with silkworm-gut. During the operation twenty-four ounces of salt solution containing adrenalin were injected into the circulation and strychnine and atropine were administered subcutaneously. After the operation the foot of the bed was raised, external heat applied, the extremities bandaged, and owing to the violent struggling of the patient morphine was given. Temperature, 100.4°; pulse, 150; respiration, 32.

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Second day: Temperature, 103.4°; pulse, 130; respiration, 56. Dressing saturated with blood-stained fluid. Unproductive cough. Strychnine, whiskey, codeine. Delirium, subsultus, carphologia. Great pain in left chest, garrulous wound.

Third day: Temperature, 100°; pulse, 130; respiration, 46. Drains removed and replaced between the edges of the skin wound because of oozing of blood.

Fourth day: Temperature, 102°; pulse, 140; respiration, 52. Passage of air through the external wound has ceased. Ammonium carbonate and digitalis.

Fifth day: Temperature, 102°; pulse, 130; respiration, 60. Examination of the chest reveals dulness, rough breathing, and crepitant rales over the lower part. Blood: erythrocytes, 3,630,000; leukocytes, 38,800; hæmoglobin, 58 per cent. The chest was explored with a needle, with a negative result.

Sixth day: Temperature, 102.8°; pulse, 140; respiration, 48. Pus under skin flap; removal of several stitches.

Seventh day: Temperature, 103.6°; pulse, 140; respiration, 52. Cough continues; little pain.

Eighth day: Temperature, 103°; pulse, 150; respiration, 50. More profuse discharge of pus from the wound.

Ninth day: Temperature, 103°; pulse, 136; respiration, 48. Chest again explored for pus, with negative result.

Tenth day: Temperature, 103°; pulse, 128; respiration, 52. Prolonged paroxysm of coughing.

Eleventh day: Temperature, 103.4°; pulse, 130; respiration, 50. Remaining stitches removed.

Twelfth day: Temperature, 103°; pulse, 128; respiration, 50.

Thirteenth day: Temperature, 100.8°; pulse, 120; respiration, 40. Small slough separating from the skin-flap.

Fourteenth day: Temperature, 100°; pulse, 120; respiration, 40.

Fifteenth day: Temperature, 101°; pulse, 120; respiration, 28. Cough almost gone; never any expectoration. Thereafter the temperature, pulse, and respiration gradually fell until on the twenty-second day the temperature registered 99°, the pulse 98, and the respiration 20. Subsequently the temperature, pulse, and respiration remained below these points. On the thirty-fifth day the patient was allowed out of bed. On the fifty-sixth day the patient was discharged to return to the Out-patient Department for dressing, a small sinus leading down to the point where the ribs were severed, still persisting; this sinus closed a few days later. The ribs have united firmly, with little callous formation. The pulse varies between 80 and 90. Adventitious sounds have never been heard in the heart. The left chest expands very little on inspiration, and slightly roughened breathing, but no rales, can still be heard.

In olden times a wound of the heart was considered synonymous with inevitable and immediate death. Ellsberg[1] tells us that prior to the sixteenth century Hippocrates, Celsus, Paul of Ægina, Roland, and Lanfranc all mention heart wounds, and agree that they are invariably fatal. In the early part of the sixteenth century Fallopius[2] studied the subject, with a view to recognizing the cavity injured, and Jacob Hollerius made the assertion that a wound of the heart was not necessarily fatal. Later in the century bullets, arrowheads, and other foreign bodies were found in the hearts of animals which had continued to run for some time after receiving their death wounds, and tales were told of men who during the intoxication of battle continued to fight after being stabbed through the heart. Toward the end of the century Ambroise Paré[3] related the oft-quoted case of the Turin gentleman who received a rapier thrust below the left nipple during a duel, and who made several passes and pursued his slayer 200 paces before falling to the ground a corpse.

In 1642 J. Wolf[2] gave the first reliable account of the healing of a wound of the heart. Morgagni[2] (1761) stated that the cause of death in many cases was compression of the heart by the effused blood, a theory which has since been converted into a fact mainly by the observations of Rose and the experiments of Cohnheim. It is interesting in this connection to recall the fact that Morgagni died of rupture of the heart.

Sherman[4] says Desault laid down the rules for pericardotomy for empyema in 1798, and it took surgery ninety-eight years to pass from the pericardium to the epicardium across a space that is such only potentially.

Benjamin Bell[2] (1783) did not believe healing could occur. A. Richter[2] (1786) considered the probe dangerous, and insisted upon absolute rest and free bloodletting. Larrey and Dupuytren laid down many rules for treatment. During the seventeenth and eighteenth centuries papers would appear describing cases in which protracted periods intervened between the injury and dissolution.

In the beginning of the nineteenth century Jamain, Zannetti, and others wrote on the viability of patients after heart wounds; but it was not until 1867, when George Fischer[5] published his classical study of 452 human cardiac wounds, that a firm foundation was laid for the evolution of the surgery of the heart. Fischer clearly established the fact that an individual might exist for hours or even days with a wounded heart; and that, indeed, in from 7 to 10 per cent. of the cases the wound heals and the patient actually recovers. Loison and Ollivier collected additional cases and corroborated the findings of Fischer. Ninni[6] states that according to the statistics of Jamain, Fischer, Lantenelet, and Zannetti, death is instantaneous in 18 per cent. of the cases.

Up until the closing years of the nineteenth century the treatment of wounds of the heart consisted in the application of an occlusive dressing, absolute rest, ice or blisters to the præcordium, sedatives, such as veratrum viride, digitalis, opium, and venesection. Rose[7] advised paracentesis of the pericardium or pericardotomy to relieve compression of the heart the result of a wound. In 1881 John B. Roberts suggested the propriety of attempting to suture a wound of the heart. Later Koenig and Delorme voiced the same opinion. The idea, however, was generally regarded as the wildest fancy of ultra-enthusiasts. Billroth declared that no surgeon who wished to preserve the respect of his colleagues would ever attempt to suture a wound of the heart. Riedinger (1884) considered the proposition below the dignity of mention. Tillmanns was convinced of the hopelessness of surgery when confronted with a bleeding heart. That the heart could be exposed and manipulated has been demonstrated by many experimenters. In 1894 Kronecker and Schmey[1] discovered that this organ might be punctured with but little interference with its action, except when a spot in the interventricular septum was touched, when immediate death ensued (Kronecker's co-ordination centre). In 1895 Rosenthal[1] essayed to treat an experimental wound of the heart by direct means—he used a tampon of iodoform gauze, and the dog survived. During the same year Del Vecchio[1] was the first to suture the canine heart with success. In 1896 Salomoni[1] and in 1897 Bode[1] successfully closed wounds of animal hearts by suture.

Since then there have been many experimental investigations into this subject. The conclusions of Elsberg,[1] which may be taken as representative of the findings of the experimenters, are as follows: That the heart could be grasped with the hands or forceps and gently compressed, with no appreciable difference in its action, and that it could be penetrated by a needle and knife, producing only a temporary irregularity of its action; that penetrating wounds produced during systole bled more than those produced during diastole, and that wounds of the ventricles produced during systole were larger than those produced during diastole; that oblique wounds bled less than perpendicular wounds; that wounds of the right ventricle were more dangerous than those of the left because the wall of the right ventricle was thinner, and also because the blood in the right side of the heart coagulated more slowly; that wounds of the heart heal kindly and that the cicatrix is usually complete in about fourteen days; that interrupted sutures are better than continuous ones; that the tissue included in the suture always atrophied, and was replaced by scar; a smaller number of muscular fibres was included in the interrupted than in the continuous suture, thus producing less atrophy and less scar tissue; that superficial sutures were less likely to tear out than deep ones, and that the sutures should be inserted and tied during diastole because of the danger of their tearing out if tied during systole.

After the road had been paved by the knowledge that patients would often live long enough for operative interference, and that the heart would tolerate manipulation, two unsuccessful attempts were made in 1896 to close human cardiac wounds by suture, one by Farina and one by Cappelen, and in 1897 Rehn published the first successful cardiorrhaphy in man. Including these cases and the one reported in this paper, I have been able to find 60 cases with the surprisingly high recovery rate of 38⅓ per cent.

Wounds of the heart may be produced by penetration from without, as gunshot or stab wounds, or by fractured ribs, and by foreign bodies from the œsophagus, stomach, or bronchus. The heart may burst as the result of blunt force to the thorax or epigastrium with or without laceration of the pericardium, and it may rupture spontaneously (disease of myocardium or coronary artery, neoplasms, gummata, echinococci, abscess, aneurysm, etc.). That an attempt should be made to save as many of these cases as survive for a sufficiently long period of time after the accident needs no argument. Of the cases thus far recorded, 55 were stab wounds and 5 gunshot wounds. Two of the gunshot wounds recovered (Launay, Noll) and in two of the fatal cases the posterior wound was not sutured (Bufnoir, Stern). As late as 1903, however, Wolff[8] advises expectant treatment in gunshot wounds of the heart.

The symptoms are those of acute anæmia or of compression of the heart, depending upon the escape of blood into the pleural cavity or externally or upon its retention in the pericardium. In some cases the patient may walk or even run for a considerable distance before falling to the ground. In a recent stab case in Philadelphia the patient was examined by a careful and competent surgeon, who regarded the wound in the chest as trivial because of the absence of symptoms. The patient died within twenty-four hours and an autopsy revealed a punctured heart. On the other hand, a patient may present marked symptoms without a serious injury. During the past year I was called to the Pennsylvania Hospital to see a boy who had been stabbed in the cardiac region. He presented all the classical symptoms of severe shock. Under a local anæsthetic the wound was enlarged and found to be non-penetrating. His symptoms disappeared in a few hours. In any case there may be nervous symptoms, such as vertigo, syncope, convulsions, vomiting, or hemiplegia (Pirogoff). The nervous phenomena are said to be more common in injuries to the left ventricle, and to be due to anæmia of the spinal cord. Respiratory difficulties are more marked in wounds of the right ventricle, but may be due to nervous influences, pneumothorax, or compression of the heart. Hæmoptysis is rare, even if the lung is injured.

When the blood escapes into the pleural cavity (the pleura was injured in 57 of the 60 cases, 95 per cent.) there will be in addition to the symptoms of anæmia the signs of a pneumohæmothorax. Palpation may detect the apex beat. A splashing sound indicates blood and air in the pericardium. A whizzing sound due to the presence of air in the pericardium is also described. In some cases a friction sound may be heard, and in others a bruit not unlike that heard over an aneurysm. The heart is apt to be irregular and in many cases the pulse is below 100°.

When the bleeding is external the stream may be continuous or in jets. Slight increase in cardiac dulness is to be expected. The respiration may be quiet until near the end, and physical examination of the lung may reveal little abnormal.

When the blood is confined to the pericardium the pulse is exceedingly feeble, and the apex beat can neither be felt nor heard. There may be a splashing sound, disappearing with the filling of the pericardium, at which time the area of precordial dulness will be vastly increased. The patient is unconscious, and may regain his senses on providing an exit for the blood. Cohnheim demonstrated by animal experiments that the pressure manifested itself first on the auricles and the origin of the great veins, producing venous stasis; this may increase to complete obstruction to the flow of blood, and is manifested by dyspnœa and cyanosis. The ventricles pump themselves dry, and the heart finally stops.

Death ensues as the result of anæmia, compression of the heart, or later from sepsis or functional incompetence. Izzo[10] reports a case of stab wound of the left ventricle which was discharged cured on the twenty-eighth day. A few hours later the patient died while lifting a heavy body, the scar having ruptured. The possibility of embolism from air or clot should also be thought of.

As may be seen from the foregoing, a diagnosis of injury of the heart may be difficult or impossible without exploration. The location of the external wound is no sure guide. Of the external wounds in the 60 cases, thirty-nine were on the left side, between the second and seventh ribs, sternum and anterior axillary line, two were in the left midaxillary line, two to the right of the sternum, one in the epigastrium, one under the left costal arch, and fifteen not mentioned. It may be stated, however, that any penetrating wound in the præcordium is almost sure to injure the pericardium or the heart. External bleeding may be profuse and spurting from a wounded intercostal or internal mammary, and may be absent in a punctured wound of the heart. Although justified by Rehn, the use of the probe is generally condemned. The statement that the blood coming from the external wound will be bright red when the left heart is injured and dark in color when coming from the right heart is not to be relied upon. Neither can the size of the wound in the heart be predicted with certainty by the size of the external wound nor the cavity injured by its location. In the present case, for instance, the cardiac wound was larger than the external wound, the knife probably entering the heart at the beginning of systole, and as the heart swung forward added an incised wound to the stab, and the location of the external wound suggested a wound of the auricle rather than the ventricle. Of the 60 cases, the left ventricle was wounded thirty times, with fifteen recoveries; the right ventricle twenty-one times, with seven recoveries; the right auricle once, resulting in death; the left auricle once, resulting in death; the apex three times, with one recovery, and in four the chamber wounded is not known. The size of the wound in the heart muscle varied from 0.5 cm. to 7 cm. The only safe procedure in doubtful cases is to enlarge the wound, ascertain if it penetrates the chest wall, and if there be symptoms of hemorrhage or "heart tamponage," operate.

Although the cases operated upon after the lapse of several hours show a larger proportion of recoveries than those operated upon earlier, operation should be undertaken as quickly as possible after the injury. Of the 60 cases, the time elapsing between the injury and the operation is not given in 29, 11 of which recovered. Of the remaining cases 16 were operated upon within one hour, with 4 recoveries, 1 in three and three-quarter hours with recovery, 4 between three and four hours with 1 recovery, 1 in five hours with recovery, 1 in six hours with recovery, 2 in eight hours with 1 recovery, 2 in twelve hours with 1 recovery, and 3 after twenty-four hours with 2 recoveries. This gives a mortality of over 76 per cent. for those operated upon within four hours, and a mortality of 30 per cent. for those after four hours. In looking over the causes of death in these cases, and leaving out of consideration 2 cases in which the interventricular septum was cut, it may be noted that of the cases operated on under four hours $35\frac{5}{7}$ per cent. died within twenty-four hours, and of those operated upon after four hours $33\frac{1}{3}$ per cent. died within twenty-four hours. An individual who survives a heart wound for a number of hours has a fair chance to recover with operation, and perhaps without operation, but of the cases which would succumb within a few hours many will be saved by prompt intervention.

The advice given by Rydygier[11] to allow a knife which may be found sticking in the chest to remain until ready to suture is questionable. It is easy to understand how the blade might produce further laceration of a beating heart.

An anæsthetic should always be employed unless the patient be unconscious. Ether was employed in the present case, because it was believed to be safer than chloroform. Of 4 cases in which ether was employed, 2 died, 1 on the table; of 11 cases in which chloroform was used, 4 died, 1 on the table; and of 11 cases in which no anæsthetic was given, 6 died, 2 on the table. Of 2 cases in which it is simply stated that an anæsthetic was administered, both died, 1 on the table.

The heart may be exposed by the extrapleural method or by the transpleural method.

Among those who have employed or who advise the extrapleural method are Rydygier, Pagenstecher, Napalkow, Wehr, Giordano, Podrez, and Nietert. Rydygier[11] advises a horizontal incision at the upper border of the third rib, extending from the right of the sternum to the left costochondral joint, then obliquely downward along the outer ends of the costal cartilages as far as the fifth interspace. The third, fourth, and fifth costochondral articulations are divided, the sternum severed subperiosteally and the flap turned to the right. Giordano suggests a vertical incision along the right margin of the sternum, with the division of the second and third cartilages; from each extremity of the vertical incision a transverse cut is made across the sternum, which is then divided and the flap turned to the left by luxating the cartilages. Podrez begins an incision in the second left interspace one and one-half inches from the sternum, carries it as far as the midsternum, then downward to the level of the seventh cartilage and outward along the seventh rib. The sternum is divided at either end of the longitudinal incision and the flap turned to the left. Nietert[12] cuts from the right border of the sternum to one inch to the left of the sternum on a level with the third rib; a similar incision is made on a level with the base of the ensiform, and the left extremities of these incisions are united by a perpendicular incision. The fourth, fifth, and sixth ribs and the sternum are divided and reflected to the right.

Among the transpleural methods are those of Del Vecchio, Parlavecchio, Farina, Rehn, Cappelen, Parozzani, Giordano, Ramoni, Ninni, and Rotter. Del Vecchio outlines an H-shaped incision: the vertical limbs correspond to the left sternal and mammary lines, and the horizontal portion to the fourth interspace. The fourth, fifth, and sixth ribs are resected, one flap being turned upward and the other downward. Farina, Rehn, Parlavecchio, and Cappelen resect one or more ribs. Parozzani made a triangular flap, one side of which extended along the left margin of the sternum from the fifth interspace to the ninth rib, the second side from the upper end of this incision outward for 3 cm.; the sixth, seventh, and eighth ribs were cut and the flap turned outward. Giordano incised in the third interspace, sectioned the third and fourth ribs, turning the one upward and the other downward. Ninni advocates an incision along the sternum from the third to the sixth rib and the same length in the mammary line, joining these by a horizontal incision in the fifth interspace. The intervening ribs are cut and the flap turned upward. Rotter cuts outward from the left border of the sternum along the third rib for two inches, then downward parallel with the left border of the sternum to the sixth rib, thence along the sixth rib to the sternum. The third, fourth, and fifth ribs are severed and the flap turned toward the right. He also advises the same procedure on the right side in cases in which the wound is on the right. The opening was made in the right chest in 3 cases only (Watten, Ninni, Barth).

The extrapleural method will be indicated in cases in which the wound does not involve the pleura, and in which the patient's condition is such as to sustain an operation protracted by the small opening in the chest wall, and by the careful manipulations necessary to avoid the pleura. This will be rare; in 3 cases only did the pleura escape injury (Pagenstecher, Nietert, Gibbon). Rehn thinks it advisable to incise the pleura to avoid negative pressure from aspirating air into the mediastinum, causing the blood to foam.

An atypical osteoplastic flap with the base toward the sternum either in the right or left chest, according to indications, and including as many ribs as may be necessary for proper exposure, usually from two to four, will probably be used in most of the future cases.

The wound in the lung ceases to bleed as a rule when the lung collapses and needs no treatment; if bleeding, it may be sutured.

The wound in the pericardium is enlarged in the axis of the heart by tearing or cutting, and the sac cleared of blood with the finger. In several of the cases attention is called to the fact that the blood coagulated behind the heart. In experimental work Ricketts found that collapse of the lung would congest the heart, and that exposure caused it to dilate because of the lack of support of the pericardium and chest wall.

The bleeding from the heart may be controlled by a finger, and the heart may be steadied by the fingers, by forceps, or by sling sutures. In the present case a suture was inserted at the upper end of the wound, tied, and used as a tractor for the insertion of the remaining stitches. In 2 cases the sutures tore out (Walker, Zulehner). Should the heart cease to beat during the manipulation it should be sutured quickly and massage performed. The use of gauze packing will probably never be indicated; to be efficient it must be firm, and to be firm it must exert injurious compression. A round, curved, intestinal needle is generally recommended. Silk was employed in 26 cases with 2 recoveries, catgut in 9 with 5 recoveries, celluloid in 1 with recovery, and in 24 the suture material is not known. The highest number of sutures employed was eleven. Silk has the advantage of being easier to manipulate and more certain to hold. It has been proven that catgut will last long enough for the repair of the wound. Silk was used in the present case because of the fear of untying of the knots by the constant gyrations of the heart. The continuous suture is mentioned in 3 of the cases with 2 recoveries. It may be applied more rapidly than the interrupted, and presents fewer knots on the surface of the heart. The sutures are inserted at intervals of one-eighth of an inch deeply into the muscle, but must not penetrate the endocardium. In dogs Sherman[4] found it a difficult matter to penetrate the endocardium with an ordinary curved needle. After tying, the ends should be cut off one-quarter of an inch from the knot to guard against untwisting. Diastolic suture is difficult and unnecessary. One would have to rehearse with a rapidly ticking metronome for a long time before he would be able to accomplish the feat. In dogs Ricketts[14] and Sherman[4] found it impossible. Although Larrey showed many years ago the possibility of recovery after a severed coronary artery, it has been asserted repeatedly that this accident is always fatal. Ricketts demonstrated on animals that either coronary artery may be ligated at any point without death resulting. Of the 4 cases in which the coronary was injured, only 1, the present case, recovered.

Any blood which may be in the pericardium is now removed by the finger or sponge, and the pleural cavity cleared of fluid and clots. The pleura and pericardium may be sutured or both cavities may be drained. Wolff[8] shows that there is no retention of secretion in the pericardium when it is closed. He explains the presence of fluid behind a tampon in Watten's case by the massage of the heart by the gauze. He says the cardiac wound heals quickly and is not infected, the instrument having been cleaned on its way through the chest wall, and he strongly advises suture of the pericardium without drainage. The dangers of the drain are the same here as elsewhere—*i. e.*, infection and adhesions. Of the 22 cases in which the pericardium was drained, 2 died within a few hours, and of the remaining 20, 10 (50 per cent.) recovered; of the 15 in which the pericardium was closed without drainage, 1 died in fifteen minutes; and of the remaining 14, 7 (50 per cent.) recovered. The question may still be regarded as an open one. In a future case I think I should close the pericardium and drain the pleura through a stab in the back, as the latter cavity is difficult to clear of blood quickly.

Of the 23 cases that recovered after operation 11 are known to have been complicated with some form of infection; in only 1 case is uncomplicated recovery stated. Of the 37 deaths, 16 occurred within twenty-four hours from shock and hemorrhage, and in 2 of these the interventricular septum had been punctured; 3 died on the second day, 2 from the infection of the pleura and 1 unknown; 4 died on the third day, 2 from infection and 2 unknown; 2 died on the fourth day, both from infection, and in 1 of these the tricuspid valve had been injured; 3 died on the fifth day from infection, and 1 on the sixth, 1 on the fourteenth, 1 on the nineteenth, and 1 on the twenty-second day, all from infection; in 5 cases the time and cause of death are unknown.

I append a table of the reported cases. (See pages 442, 443.)

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TABLE OF CASES OF CARDIORRHAPHY.

Operator and year.	Location of external wound.	Chamber wounded and size of wound.	Time between injury and operat'n.	Anæsthetic.	Suture.	Drainage	Result and remarks.
1. Farina, 1896	Just above margin of left 6th rib, near sternum.	R. v., ¼ in.	Immediately.	......	3 silk sutures.	Suture of pericardium.	Death 6th day; bronchopneumonia.
2. Cappelen, 1896	4th left intercostal space in midaxillary line.	L. v., 4/5 in.; left coronary artery sever'd	1 hour.	......	....	....	Death 2½ days; pericarditis.
3. Rehn, 1897	4th left intercostal space near sternum.	R. v., 1½ cm.	24 hours.	Ether.	3 silk stitches	·Drain of pleura and pericard'm	Recovery; empyema.
4. Parozzani 1897	7th left intercostal space in midaxillary line.	L. v., ¾ in.	5 hours.	None.	2 silk sutures.	None.	Recovery.
5. Parozzani 1897	3d left intercostal space.	L. v., 3/5 in.	½ hour.	None.	2 silk sutures.	....	Death 24 hrs.; interventricular septum cut, also pleurisy on l.side.
6. Fummi, 1898	Under left nipple.	Apex, cavity not opened.	Several hours.	......	1 silk suture.	....	Recovery; empyema.
7. Ninni, 1898	5th left intercostal space, mammary line.	L. v., 1 in.	Immediately.	None.	2 silk sutures.	No drain pericard'm.	Death on table.
8. Parlavecchio, 1898	5th left intercostal space.	L. v., 1½ in.	8 hours.	Chloroform.	....	No drain.	Recovery.
9. Giordano, 1898	2d left intercostal space.	L. a., 4/5 in.	½ hour.	None.	4 silk sutures.	Drain of pleura.	Death 19th day; empyema and abscess r. lung.
10. Williams, 1898	....	L v., not penetrating.	....	......	....	....	Recovery.
11. Nicolai, 1899	4th left intercostal space, mid between sternum & nipple.	R. v.	1½ hrs.	Yes.	....	....	Death after 12 hours.
12. Tuzzi, 1899	4th left intercostal space.	2 wounds, non-penetrating.	....	None.	....	Drain of pleura and pericard'm.	Death 22 days; empyema and pericarditis.
13. Longo, 1899	5th left intercostal space 2/5 in. internal to nipple.	L. v.	Immediately.	None.	3 silk sutures.	No drain of pericard'm.	Death in 15 min.
14. Ramoni, 1899	3d left costal cartilage 4/5 inch from sternum	R. v., 2 w'ds, 1 non-penetrating.	....	None.	4 silk sutures.	No drain of pericard'm, pleura dr.	Recovery.
15. Marion, 1899	Shot through breast.	R. v.	....	......	Catgut sutures.	....	Death.
16. Rosa, 1899	5th intercostal space.	L. v., 3/5 in. not certain it penetrat'd	....	None.	1 silk suture.	Drain of pleura and pericard'm.	Recovery.
17. Horodynski, 1899	....	R. v., 1½ cm.	....	......	....	....	Death.
18. Maliszewski, 1899	....	....	....	......	....	Drain of pericard'm.	Death; suppurative pericarditis.
19. Maliszewski, 1899	....	....	....	......	....	Drain of pericard'm.	Death; suppurative pericarditis.
20. Bufnoir, 1899	6th left intercostal space.	R. v., gunshot, 22 calibre.	....	... ..	....	....	Death; perfor'n of ventricle, and ant. opening only had been sutured
21. Kosinki, 1899	....	R. v.	....	......	....	....	Recovery.
22. Pagenstecher, 1899	4th left intercostal space beneath nipple.	L. v., near apex, 1 2/5 in.	2 days.	None.	4 celluloid sutures.	Drain by threads from myocardium.	Recovery.
23. Nanu, 1900	3d intercostal space 4 cm. from edge of sternum.	R. v., 2 cm	....	......	2 interrupted sutures. of silk.	....	Death 5th day from infection of pericardium and pleura.
24. Masselli, 1900	Below and internal to left nipple, cutting 6th rib.	L. v., near apex.	1½ hrs.	None.	2 sutures	Drain of pleura.	Death in 12 hrs.
25. Fontan, 1900	6 wounds between 3d and 7th ribs in cardiac region.	L. v., 12 mm.	6 hours.	Chloroform.	2 continuous catgut sutures.	No drain, suture of pericard'm.	Recovery.
26. Carnoble, 1900	....	Apex.	....	......	Catgut.	....	Death in 5 days; empyema.
27. Nietert, 1901	Right of sternum.	R. v.	2 hours.	None, unconscious.	2 silk sutures.	Drain of pericard'm.	Death in 33 hrs.
28. Vaughan, 1901	5th left costal cartilage divided.	L. v., 2½ cm.	¾ hour.	Ether.	7 continuous silk sutures.	....	Death on table.
29. Ninni, 1901	Left of sternum.	R. a.	....	......	....	....	Death in 4 days; sepsis.
30. Mignon et Sieur, 1901	....	R. v.	....	......	....	....	Death.

Operator and year.	Location of external wound.	Chamber wounded and size of wound.	Time between injury and operat'n	Anæsthetic.	Suture.	Drainage	Result and remarks.
31. Fontan, 1901	....	L. v.	....	......	Catgut sutures.	Suture of pericard'm.	Recovery; empyema.
32. Brenner, 1901	Left of sternum near 6th cartilage.	R. v., 7 cm.	Following day.	Yes.	....	....	Death on table.
33. Watten, 1901	4th right intercostal space.	R. v., 3½ to 4 cm.	....	......	....	Drain of pericard'm.	Recovery; right pleura wounded, pneumothorax.
34. Lastaria, 1901	....	L. v.	....	......	....	....	Death in 12 hrs.
35. Zulehner, 1901	....	L. v., ½ cm.	....	......	....	....	Death on table.
36. Zulehner, 1901	....	R. v. 1 cm.	....	......	Catgut sutures.	....	Recovery.
37. Stern, 1901	....	L. v., pistol wound.	....	......	Unable to suture posterior wound.	Gauze tampon.	Death in 30 min.
38. Pagenstecher, 1901	In heart region.	L. v., left coronary artery injured.	....	......	....	Drain of pericard'm.	Death in 5 days; pus in pleura and pericard'm.
39. Ninni, 1901	....	L. v.	....	......	....	....	Recovery.
40. Walker, 1901	....	L. v., 8 stab wounds.	....	......	11 silk sutures.	Drain of pericard'm.	Death in 24 hrs.; pyothorax and pyopericardium.
41. Walker, 1901	Under left costal margin.	Apex r. v.	....	......	Suture tore out repeatedly.	Gauze tampon.	Death in ½ hr.; hemorrhage.
42. Nietert, 1902	Left 6th intercostal space to right of papillary line.	L. v., 2 cm.	14½ hrs	Chloroform.	2 silk sutures.	Drain.	Recovery; empyema.
43. Launay, 1902	Left nipple.	L. v., ant. & post. walls, pistol shot.	3½ hrs.	Chloroform.	Catgut suture in each wound.	Drain of both cavities.	Recovery; uncomplicated.
44. Gibbon, 1902	Left præcordium.	R.v., 1.5 c.m.	½ hour.	Chloroform.	1 catgut suture.	....	Death on table.
45. Hill, 1902	5th intercostal space a little to right of nipple.	L. v., ⅜ in.	8 hours.	Chloroform.	1 catgut suture.	....	Recovery.
46. Stewart, 1902	4th intercostal space ½ inch left of sternum.	L. v., ⅝ in.	Immediately.	Ether.	6 catgut sutures.	....	Death in 3 days.
47. Pomara,[15] 1902	....	....	....	......	....	....	Death in a few days.
48. Milesi,[16] 1903	Upper border 6th rib 1.5 cm. from left border of sternum.	R.v., 1.5 c.m.	½ hour.	......	Silk suture.	Drain of pleura and pericard'm.	Death in 15 hrs.; punct. interventricular septum.
49. Giordano[17] 1903	2 wounds, 1 in 4th and 1 in 6th intercostal space.	L. v., 2 cm. long.	....	......	2 silk sutures.	Drain.	Recovery; necrosis of ribs.
50. Giordano[17] 1903	6th intercostal space 1 cm. left of nipple.	L. v., near apex.	....	......	2 silk sutures.	Drain.	Death in 1½ hrs.
51. Vince,[18] 1903	5th left intercostal space in parasternal line.	L. v., 6 cm., coronary arartery injur'd during suturing.	About 12 hours.	Chloroform.	3 silk sutures.	No drain of pericardium, drain of pleura.	Death 2d day; pneumonia and pleurisy.
52. Janari,[19] 1903	3d left intercostal space bet. ant. axillary & mam. lines.	L. v., 2 cm.	¾ hour.	Chloroform.	3 silk sutures.	Drain of pericard'm.	Death in 74 hrs.; pleurisy.
53. Barth, 1903	Epigastrium and through ensiform.	R. v., 2 cm.	Soon.	Chloroform.	4 silk sutures.	Drain of pleura and pericard'm.	Death 4th day; sepsis tricuspid valve injured.
54. Barth, 1903	4th left intercostal space 3 cm. from sternum.	L. v., ½ cm.	Soon.	Chloroform.	3 silk sutures.	Suture of pericard'm.	Recovery, with pleurisy.
55. Barth, 1903	3 cm. above and inside nipple.	R. v., ¾ cm.	....	Chloroform.	5 silk sutures.	Suture of pericard'm.	Recovery, with pleurisy.
56. Schwerin[20] 1903	4th left intercostal space.	R. v.	¾ hour.	......	3 silk sutures.	Drain.	Recovery; pyopericardium.
57. Noll,[21] 1903	Revolver wound 5th left intercostal space.	L.v., ant. wall sutur'd, post. not ment'n'd.	1½ hour.	......	....	Drain.	Recovery; empyema.
58. Wolf,[22] 1903	....	R. v., 2 cm.	....	......	....	Drain.	Death in 14 days; empyema.
59. Stude,[23] 1904	Left breast.	L. v., 1 cm.	1¾ hour.	......	Silk suture.	....	Death on table.
60. F. T. Stewart, 1904	2d intercostal space 1 inch left of sternum.	L. v., ¾ in., coronary artery injured during suturing.	¾ hour.	Ether.	6 continuous silk sutures.	Drain.	Recovery; pneumonia and infection of wound in chest wall.

Cases 1 to 46 inclusive and Cases 53, 54, and 55 are taken from Hill[10] and Wolff.[8]